# LIGHTING DATA

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY

GENERAL SALES OFFICE HARRISON, N. J.

# The Lighting of Office Buildings and Drafting Rooms

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INDEX 35 MAY, 1920 BULLETIN L. D. 103

SYNOPSIS:



For information regarding MAZDA lamps and lighting questions, refer to the nearest sales office.

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# *The Lighting of Office Buildings and Drafting Rooms*

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## *Introductory*

There is no doubt that a fruitful field for improvement exists with this class of service. Recent tests in industrial plants have proven beyond a shadow of doubt a condition that engineers have recognized for a long while: that proper high intensity lighting increases production.

In the industrial plant with high intensity illumination, the workman has an increased quickness of perception, he sees all parts of the machines with ease, he does not lose time hunting about in shadows for the next piece of work or tool, he is not fatigued through eye strain and he has the confidence which always comes with clear visual conditions.

FIG. 1

Illustrating the Effect of Specular Reflection from a Polished Surface. The book at the right has matt paper, the one at the left glossy. The camera is placed at the position of the eye. It is impossible to see the printing on the glossy paper

The same general conditions prevail in the office, although they are not as universally recognized. With too low an intensity of lighting the eye is soon fatigued, particularly when engaged in clerical work. With glaring light sources or glaring reflections from the work or surroundings, the efficiency is seriously impaired. With dancing or shifting shadows on the typewriter or ledger, eye strain is introduced. These effects are particularly serious in the clerical or stenographic office where a high percentage of women are employed, for they are by nature particularly sensitive to such effects.

Properly installed high intensity lighting in the office will increase production and reduce the number of absentees.

A careful consideration of the subject shows past standards of intensity to be too low. An analysis of the standards recommended in typical text books and handbooks shows the average values set down as desirable to be between three and four foot-candles.

You can, of course, see to read or typewrite with less than one half a foot-candle, but severe eye strain is introduced, and no one

FIG. 2

General Direct Lighting in a Clerical Office. Small MAZDA lamps are employed in prismatic bowl-shaped reflectors. These are closely spaced and provide a high intensity of illumination. The light at any point is received from a number of sources. The inner surface of the reflector is etched and lamps are bowl frosted giving a diffused quality to the illumination. A neat stem fixture is employed

would think of insisting on prolonged work under such conditions. Where, then, is the economic or critical limit to intensity? One hesitates to say, and can merely report that the most progressive firms are using, and the leading specialists are recommending, from 10 to 15 foot-candles for general clerical work. What the standard will be a decade from now cannot be accurately foretold.

One often hears the criticism that a certain place is over-lighted, and a much quoted report of some medical men who investigated

office lighting conditions in lower New York City, characterized the majority of them as "over-lighted." A subsequent casual investigation revealed this same general group of buildings to be even below the standards then prevailing for good office lighting.

*Glare* is the element of lighting which causes the layman to refer to a place as over-lighted. These offices were in general glaringly lighted. Glare is the element we must watch out for if we are to see higher standards of intensity prevail.

Not only does good illumination offer real benefits to the

FIG. 3

This Mailing Department Has General Illumination of the Direct Type with a Few Auxiliary Desk Lamps. The ceiling is 14 ft. high of a light cream color, while the walls are buff. 150-watt bowl frosted Edison MAZDA lamps in deep bowl, light density, opalescent glass reflectors are placed 11 ft. above the floor. Outlets are spaced on centers 12 by 15 ft. (0.8 watts per sq. ft.). The intensity of illumination is somewhat over 4 foot-candles. The effect is pleasing, lamps are well out of view and there is sufficient general illumination so that the desk lamps are seldom used

occupants of the building, but the building owner in turn receives his share through the advertising value of good illumination which has long been recognized by the merchant, and the up-to-date store owes much of its popularity to brilliant lighting. The shop keepers have been forced by competition to raise their standards of illumination. The well lighted office building attracts and holds

tenants. This statement applies not only to the offices proper, but to the entrances, passageways and the like. The modern office building is constructed with its entrance or lobby elaborately decorated and finished in a manner to attract. It should have its lighting so designed that the architectural beauty will be supplemented. Ornate and novel design of fixtures and glassware is of importance here. One's first impressions are always most marked and, if the entrance to a building has drawing power, a decided advantage is obtained.

## *Method of Lighting*

A few years ago each desk had a portable lamp directly above it and a few overhead units. This is what is termed a combination of local and general illumination. It was a necessary condition, since the lamps were not efficient enough to warrant supplying a sufficiently high intensity throughout the entire room. An office with a multiplicity of drop lights is unsightly, the cost of wiring is high, and there is a heavy expense when wiring is changed as the position of the desks are shifted. The employees are likely to change the location of lamps by tying the wire to some stationary object, a practice which is objectionable from a standpoint of safety and forbidden by the wiring codes.

Local lighting is objectionable as there is a great liability of glaring reflections from the desk surfaces and glazed paper; the clerk loses time shifting the light about, breakage of lamps is increased, and there is often marked contrast between the brightly lighted desk area and the rest of the room which does not make an efficient condition. Now, therefore, general illumination is practically standard. Overhead units alone are used—lighting the whole room uniformly—so placing the lamps that they are well out of the ordinary angle of view, equipping them with diffusing glassware, and arranging them in such a manner that dense shadows are avoided. This scheme also permits the use of larger lamps, which, as a general thing, are more efficient than the smaller sizes. Since fewer outlets are required the cost of wiring is reduced. A great deal of careful investigation has proved, without doubt, that general illumination is a real economy, all things considered, in comparison with local lighting.

Good office lighting provides a high intensity of light. Lamps are so arranged and equipped that annoying shadows are avoided. There must be no objects of high brightness in the field of view to

distract the attention and fatigue at the eye. Undue contrast between light sources and the background against which they are seen or between any adjacent surfaces in the field of view is objectionable.

The MAZDA C lamp (see Bulletin Index 1), on account of its high efficiency, low maintenance cost, convenience of control, steadiness, pleasing color of light and wide range of sizes available, is practically the standard illuminant for office lighting.

FIG. 4

Common Sense Office Lighting of a Modern Type. In this large clerical office, 150-watt clear MAZDA C lamps are used on 10-ft. centers, 4 outlets per bay. The resultant illumination is slightly over 9 foot-candles. A deep, dense, opal, inverted reflector is employed. This unit carries out all the principles outlined in the text regarding the choice of a semi-indirect fixture

The types of auxiliary glassware or reflectors now standard are many, as indicated in Bulletin Index 22, varying from the efficient prismatic and mirrored glass types to the purely decorative light density opalescent enclosing units which have practically no reflective properties. A reflector is required for two purposes: in the first place, all commercial light sources are far too bright to be looked at for any length of time, hence the light rays must be broken up or diffused, or else the eyes protected entirely from direct

light. The other property of the reflector is to send the light in a certain direction, making the lighting system as efficient as possible by directing the light where most needed.

The question of the proper *color* of *walls* and *ceiling* is of such importance that it is deemed advisable to treat it rather completely in a separate Bulletin Index 15.

Data on the comparative efficiencies of various lighting systems under different conditions and information on the methods of

FIG. 5

A Pleasing Semi-indirect Installation in a Medium Sized Office. A somewhat decorative type of opalescent glass bowl is employed in this instance. 200-watt MAZDA C lamps on 10-ft. centers produce an intensity of over 12 foot-candles. The ceiling is evenly illuminated and the glassware is sufficiently dense to prevent glare

calculating a lighting installation is to be found in Bulletin Index 13.

Whatever lighting system is installed it is absolutely necessary to maintain it well if satisfactory service is to be secured. Some strikingly interesting data on this phase of the lighting question will be found in Bulletin Index 14.

## *Comparison of Systems of Lighting*

There are now three methods generally accepted of supplying the light, known as direct, semi-indirect and totally indirect. With direct lighting a reflector is placed above the lamp, or an enclosing globe around it, sending the larger part of the light at once to the desk level.

A semi-indirect unit consists of a translucent dish, bowl or reflector placed below the lamp, sending most of the light to the ceiling, from which it is reflected downward, but allowing part of the light to be diffused through the glass.

A totally indirect unit consists of an opaque reflector below the lamp, sending all of the light to the ceiling.

Direct lighting with efficient reflectors is unquestionably the most economical, as far as current consumption is concerned, of the three methods, for with it the color of walls and ceilings have less effect on the resultant illumination. Direct lighting, if improperly arranged, may produce glare either from the light sources themselves or by reflections from the objects lighted, or it may distribute the light unevenly and as a result produce dense shadows. It is not generally as decorative as the other methods. Nevertheless, thousands of satisfactory installations of good direct office lighting are to be seen, employing translucent glassware rather than opaque reflectors, thus avoiding the undesirable condition of a dark ceiling and the gloomy appearance of the room. Many forms of semi-enclosing glassware of the direct type are giving very satisfactory service.

Totally indirect lighting is probably the most "fool-proof" from the stand point of aglaring installation. The light is usually evenly distributed and comfortable. Objections have been raised that there is a total absence of shadow, making the room appear flat. If the system is properly designed, however, this is not true.

Semi-indirect lighting is an intermediate practice; it is more efficient than totally indirect and much better for the eye than the average direct-lighting system. Semi-indirect lighting is not glaring if the proper unit is chosen; it can be made very decorative, the light is quite evenly distributed and such shadows as are produced are very soft and do not become annoying. The fact that the place where the light originates is readily discernible, has a psychological effect on the average individual and makes many people feel more at ease under semi-indirect lighting than under totally indirect.

A semi-indirect unit, first, should be of quite dense glass; in other words, transmit but a small portion of the light, if the best conditions for the eye are to be obtained. If light density glass is used, the bowl becomes very bright and the system loses many of its advantages, dropping back to the direct lighting class where a number of fairly bright objects are in the field of vision.

Second, the fixture or hanger used should be of such a length and the socket in the proper relative position to the bowl that the light is directed in such a manner as to illuminate the ceiling evenly. Many cases can be noted where the lamp is placed too low in the dish, concentrating the emitted light in a fairly narrow angle resulting in a ring or circle of very bright illumination on the ceiling directly above the unit with the spaces between units comparatively dark. At other times to get rid of this effect, the lamp is raised so high that from some parts of the room the filament becomes visible, introducing glare. On the introduction of the MAZDA C lamp with its rather concentrated filament, this feature became of more importance than formerly.

Third, the glass used should be smooth inside and, preferably, outside, as roughed glass collects dirt very readily and is difficult to clean. Needless to say, all lighting fixtures should be regularly and carefully cleaned to keep the illuminating efficiency at a maximum.

Fourth, the means of suspension of the bowl should be such that there is absolutely no danger of the glassware falling and it is desirable to have some convenient means of cleaning.

The primary purpose of the fixture is to support the lamp and glassware and in most commercial installations should be as simple as possible, of plain, well finished metal. In a decorative interior, such as a director's office, the ornateness of the fixture is of more importance and its artistic value should be given due consideration.

Fifth, in the commercial office the decorations of the glassware, if any, should be very simple, for any appearance of excessive ornateness would be out of keeping with the character of the room. Deep crevices in the glass, although they may be decorative, are objectionable from the standpoint of dust accumulation.

With indirect or semi-indirect systems it is very essential that the ceiling be light in color, white or slightly cream, to secure the maximum efficiency or reflection.

The following table gives the approximate percentage of light, generated by the lamps, which may be expected to reach the desks

under different conditions in rooms of average size, say, above 20 by 20 ft. These values are called utilization constants. The method of applying them to a specific problem will be found in Bulletin Index 13.

| CEILING | LIGHT | | MEDIUM | |
|---|---|---|---|---|
| Walls | Light | Medium | Light | Medium |
| Prismatic glass direct | 0.60 | 0.53 | 0.52 | 0.48 |
| Opalescent glass direct | 0.50 | 0.45 | 0.44 | 0.42 |
| Totally indirect | 0.32 | 0.30 | 0.23 | 0.20 |
| Semi-indirect | 0.38 | 0.34 | 0.28 | 0.24 |

FIG. 6

Night View of Totally Indirect Lighting in a Small Private Office. In this installation each outlet supplies 3 75-watt MAZDA C lamps which are placed in mirrored inverted metal reflectors concealed in a spun metal housing. The intensity of illumination is approximately 9 foot-candles. The room is attractive in appearance. Glaring light sources or reflections are entirely eliminated

## *Spacing of Outlets*

Many rules will be found in textbooks and handbooks as to the spacing of outlets equipped with different types of reflectors. The ratios given between hanging height and distance apart take

into consideration the securing of uniform illumination. Uniform illumination, however, is not the only factor which must be given consideration. For example, with extensive reflectors, the statement is made that they can be spaced twice as far apart as their distance above the working plane. In other words, with a 10-ft. ceiling, a maximum spacing of approximately 14 ft. would be permissible. Direct lighting units on 14-ft. centers in a room with a 10-ft. ceiling would *not* provide satisfactory office lighting. The shadow effects would be too great. For satisfactory illumination, it is desirable to have the illumination on a given desk or table received from several sources. This introduces what might be termed "cross lighting" and tends to eliminate shadows.

In practice a rough general rule, "never space outlets much further apart than the ceiling height," works out quite satisfactorily.

In planning the location of outlets, it is desirable to space these symmetrically with regard to the bays or columns. The number of outlets per bay will, as stated above, depend on the ceiling height. Standard construction is tending toward 20-ft. bays in office buildings and for the ordinary heights of ceiling 4 outlets per bay are to be preferred. If the bays run larger than this it is often advisable to increase the number of outlets to 6, as future demands may necessitate the dividing of the large space into two or more small offices. The 6 outlets per bay arrangement often meets these conditions without necessitating any additional wiring. In some cases additional outlets are provided, but not fitted with fixtures (the outlet box merely being covered with a neat cap) to make provisions for the future and avoid the necessity of opening the ceiling for rewiring.

In cases where an unsymmetrical arrangement of outlets is necessary, they should be located relatively nearer the windows than the inside wall for the predominating light will then come from the same direction as daylight.

In wiring large offices lamps should be controlled in rows parallel to the windows rather than in groups perpendicular to the windows. In this manner the center of a wide room which has the first demands for artificial light, can be turned on before light is required nearer the window.

It is very rare that an office can be lighted satisfactorily by one outlet, and even a small clerical office should have from 2 to 4 outlets, depending on its size.

### *Wattage Required*

Modern practice for large clerical offices supplies the following approximate watts per square foot:

Direct lighting with efficient dense opal or prismatic reflectors and bowl frosted or bowl enameled MAZDA C lamps, 1.25 to 1.75 watts per square foot.

Direct lighting with semi-enclosing units such as the Ivanhoe Ace, the Brascolite, the Denzar, the Four-in-one unit, etc., with clear MAZDA C lamps, 1.5 to 2.0 watts per square foot.

FIG. 7
Sanitation is Improved with High Intensity Illumination. 60-watt bowl frosted Edison MAZDA lamps in deep bowl, dense, opal reflectors provide adequate lighting in this toilet

Semi-indirect, dense, opal or mirrored glass totally indirect units with clear MAZDA C lamps, 1.5 to 3 watts per square foot.

Where work is likely to be done with faint figures requiring close scrutiny, the higher values apply. Light ceilings and walls will give the maximum illumination with a given expenditure of power.

In small rooms, since a greater proportion of the light strikes the walls, less illumination will be effective than in a large room with the same size lamps and same equipment.

For private offices, it is often very satisfactory to provide a relatively low intensity of general illumination by some decorative central unit and use a localized light of satisfactory design for the desk. This should be located in such a manner as to prevent

glaring, annoying reflections. In any offices where glass tops are used on the desks, particular attention must be paid to the type of lighting fixtures to avoid reflections.

### *Drafting Rooms*

Although the lighting requirements of the drafting room are somewhat exacting, they may be readily met if due care be taken in the selection and location of lighting units. The ideal condition

FIG 8

Night View in a Large Drafting Room Lighted by Duplexalite Semi-indirect Fixtures with 200-watt MAZDA C Lamps, 2 Outlets per Bay. It is interesting to note the special design of window blinds which direct and diffuse daylight and reflect such artificial light as strike them

is an even distribution of well diffused light of a high intensity. Shadows must be minimized as they make it difficult to follow the fine lines when working close to the T square or triangle.

A high intensity of illumination is necessary. Five foot-candles is the minimum and should be supplied only for rough work. For the most exacting work, such as tracing from blue prints, from 10 to 20 foot-candles will be required.

The discussion given under office lighting applies to the drafting room. The requirements are even more exacting as the work is of a higher grade and must be accurate. Semi-indirect systems where dense glass is employed, or totally indirect systems are probably the best suited, using from 1.5 to 3.5 watts per square foot.

Direct general illumination of a high intensity using rather close-spaced semi-enclosing units is also used, where the ceilings are so dark as to preclude the use of indirect systems, and found satisfactory. The units should be located with reference to the

FIG. 9

A High Intensity of Illumination is Provided in This Drafting Room by 300-watt Clear Edison MAZDA C Lamps in Deep Bowl, Dense, Opal, Inverted Reflectors. This type of illumination gives excellent diffusion and eliminates dense shadows The high intensity of lighting is most efficient and makes the clumsy desk lamp unnecessary

drawing tables and so arranged that the maximum light will come from the proper direction. Lamps must be hung well out of the angle of vision and every effort made to avoid glare.

In both the direct and semi-indirect systems of illumination due note must be taken of the usual arrangement of boards relative to the windows, locating the lamps so that, as far as possible, the direction of predominant light is the same as that of daylight.

A system which is quite frequently found is the use of a diffused general illumination (1 to 2 foot-candles) supplemented by a local

lamp for each drawing board. This unit may be of several varieties, fixed or movable, attached to the wall or to the drawing board, opaque or diffusing reflector, and various sizes of lamps; but in any case it is open to the usual objections of local lamps, namely, liability of glaring reflections, loss of time in shifting the lamps, and relatively high maintenance cost.

Tracing may often be satisfactorily accomplished by having the top of the tracing table made of etched glass, and lamps with suitable reflectors placed below the glass, illuminating the work from beneath rather than from above.

### *Lighting of Corridors*

The primary function of corridor illumination is to provide enough intensity for anyone to pass along without danger of stumbling or interfering with another person. This, of course, can be accomplished with low candle-power lamps spaced quite widely and equipped with diffusing glassware or reflectors, giving a wide spread of the light, as uniform illumination is not necessarily essential. This arrangement, while satisfactory for an industrial plant or basement, however, does not fulfill the conditions as they ordinarily exist in the large office building.

The important feature of corridor, entrance and lobby lighting is its advertising value. If the prospective tenant gets a favorable opinion of a building on entering its attractive lobby, the desirability of renting in that building is impressed upon his mind. The lighting fixture is one of the vital parts of this equipment. Brightly lighted lobbies and entrances, through which everyone must pass several times a day, are not only desirable but from this viewpoint essential. The lighting should supplement the architectural decorations and not appear merely as a makeshift.

Not only is the drawing power of good illumination a factor, but a fair intensity of light is really needed, for it is necessary to distinguish the numbers of the rooms and read the names of the occupants. For this reason lighting units should be located in front of the doors which will make the maximum spacing not over 20 feet.

Most buildings are so constructed that the partitions along the corridors are of translucent or ribbed glass. The lamps placed in the hallways assist in the office lighting and are particularly valuable in building up the illumination in the darkest part of the room, namely, opposite the windows.

A row of outlets, symmetrically spaced along the center line of the ceiling, is generally to be preferred and any of the three systems, direct, semi-indirect or totally indirect, will prove satisfactory. Which one is used will depend largely on the office lighting itself, for it is advisable to have the building harmonious throughout.

Often the building is so laid out as to make ceiling outlets inadvisable. In this case bracket or wall fixtures must be employed.

Chairs for the reception of salesmen or other visitors are often located in the corridors. One usually attempts to read while

FIG. 10
An Office Building Corridor Well Illuminated by 60-watt MAZDA Lamps in Stalactite Enclosing Globes on 15-ft. Centers. These are neat, yet decorative

awaiting an appointment and if adequate lighting is not provided this is difficult, and time drags heavily with resultant irritation.

## *Miscellaneous Uses of Light*

The uses of light in and about an office building are many, and it is impractical to go into detail on all of these.

Electric signs on the exterior of the building cause it to become well known, and the value of the sign has been demonstrated

before now. A number of the prominent office buildings have their names outlined in glowing lines of flame visible for miles. The electric sign is also most useful in the building itself, designating the direction of offices, exits, elevators and the like. The subject of sign lighting is discussed at length in a separate Bulletin, Index 92.

Floodlighting has come to the foreground very rapidly in the last few years, although many important installations were made some time ago. For example, the Singer Tower strikingly illuminated by arc projectors, is recognized as one of the beauties of Greater New York. Properly designed floodlighting illuminates the entire exterior of the building to the proper intensity, causing it to stand out against the dark background formed by the sky.

FIG. 11

Efficiency of Business is Enhanced by the Proper Illumination of the File Room. This storage vault is illuminated by 50-watt MAZDA lamps in porcelain enamel steel dome-shaped reflectors. They are regularly spaced between rows of shelving. The central aisle is continuously illuminated and it is interesting to note conveniently located snap switches at the end of all transverse aisles promoting economy of lighting

Recent developments in incandescent lamps have made floodlighting with incandescent lamps very practical and some of the most prominent buildings in the country are so illuminated. For example, the Woolworth Building on Broadway, New York City. This field of lighting, also, is treated in another publication, Index 95.

Safety demands that the stairways be well lighted. It is advisable to provide an outlet at each landing. Medium-sized lamps are adequate and should be equipped with diffusing glassware of a decorative nature.

Elevators should, of course, receive attention, for unless the floor and edge of the car is clearly visible there is danger of stumbling. For the general illumination of the car itself, it is customary to provide a diffusing glass hemisphere at the center of the roof of the car, equipped with two small lamps; then, if one should fail the other will still be in service. There are a number of methods in use in the most recent buildings of illuminating the edge of the car. One of these consists in having a perforated plate with glass insets and lamps below the floor shining up through this plate; another scheme is arranged so that when the car is stopped a small lamp, enclosed in a reflecting device at the side of the door, is turned on, sending a beam of light across the floor.

The operating departments present problems akin to the machine shop, wood working plant and the like, which subjects are fully discussed in Bulletins Index 62 and 63.

It is not practical to go into details of wiring or to specify methods of providing auxiliary outlets, but it should be borne in mind that the uses of electricity are diversified; convenient side wall and baseboard receptacles are necessary for the attachment of electric fans, portable lamps, small motor devices, vacuum cleaners and similar apparatus.

Electric incandescent lamps are used in many places for signaling devices as demonstrated in the elevators, and it is often advisable in the busy office to install communicating systems where miniature lamps light up when the person is called, thus doing away with the annoyance attendant on the ringing of a bell or buzzer.

## *The Foot-candle Meter*

The Foot-candle Meter is a compact, convenient, easily operated, portable photometer selling for $25. It enables one to determine the intensity in illumination in foot-candles at any point. It should prove invaluable to the building manager. If his tenants complain of inadequate lighting, he merely has to go to the office from which the complaint originates, lay the Foot-candle Meter on one of the desks and prove his case by comparing the actual illumination with the established standards.

He can tell if the porters are attending to their duties in cleaning lamps and glassware by making periodic readings of illumination. These are only a few of the uses in which this instrument is of great value in rendering satisfactory service and keeping tenants contented.

## *Bibliography of Literature on Office Lighting*

The following list is an index of leading articles treating the general subject of office lighting which have appeared in the prominent technical magazines during the past few years:

"Indirect Illumination of Large Office Buildings," Aldrich and Malia, Transactions Illuminating Engineering Society, Vol. 9, page 103.

"Engineering Features of Office Building Lighting," by Edwards and Harrison, Transactions Illuminating Engineering Society, Vol. 9, page 164.

"Semi-direct Office Lighting in the Edison Building of Chicago," by Durgin and Jackson, Transactions I. E. S., Vol. 10, page 690.

"Lighting in Downtown Office Buildings," by Dicker and Kirk, Transactions I. E. S., Vol. 10, page 659.

"Choice of a Semi-indirect Unit for Office Lighting," by A. L. Powell, *Lighting Journal*, May, 1916.

"A Study of the Economics of Office Building Lighting," by S. G. Hibben, Transactions I. E. S., Vol. 11, page 976.

"Kinks and Stunts in Office Building Lighting," by S. G. Hibben, *Electrical Journal*, June, 1917.

"Illumination of Business Office Spaces," by C. E. Clewell, *Electrical World*, July 14, 1917.

"Lighting of the General Offices of the Consolidated Gas Company," by T. Scofield and C. L. Law, Transactions I. E. S., Vol. 12, page 205.

"Economics in the Operation of Large Lighting Installations," by C. L. Law and J. E. Buckley, Transactions I. E. S., Vol. 13, page 83.

"Lighting of Offices and Drafting Rooms," by Ward Harrison, *Electrical Review*, May 18 and 25, 1918.

"Modern Practice in Office Lighting," by A. Wise, *Illuminating Engineer* (London), February, 1919.

"Modern Office Lighting," by A. L. Powell, *Electrical World*, February 15, 1919.

"The Lighting of Offices, Stores and Shop Windows," by Norman Macbeth, Illuminating Engineering Practice Lectures, page 363, McGraw-Hill Publishing Co.